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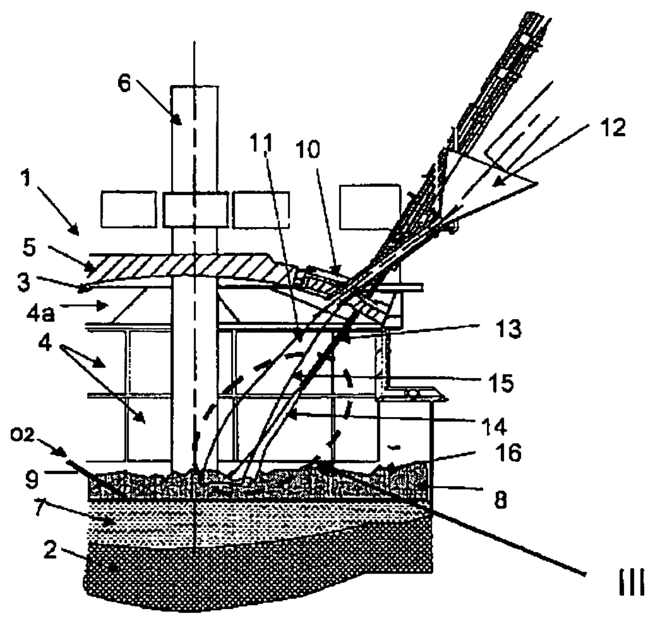
(54) Title: PROCESS FOR MELTING SPONGE IRON AND ELECTRIC-ARC FURNACE FOR CARRYING OUT THE PROCESS



(57) Abrégé/Abstract:
In a process for melting down sponge metal (11) in an electric-arc furnace (1) having at least one electrode (6), the sponge metal (11) is introduced into the electric-arc furnace (1) under formation of at least one sponge metal jet (15) which in the immediate vicinity of an electrode (6) hits the bath level (16) present in the electric-arc furnace (1), and for decarburization and/or intermixing the bath and/or charging energy oxygen is blown into the melt (7). For a CO post-combustion, in addition to the oxygen introduced for decarburization and/or intermixing the bath and/or charging energy into the melt at least one jet (14) of oxygen or one jet (14) of an oxygen-containing gas is blown into the electric-arc furnace (1) at a low rate, which jet hits the bath level (16) in the region of the point of incidence of the sponge metal jet (15), which preferably is conveyed into the electric-arc furnace (1) by gravitation alone, and/or immediately adjacent to the point of incidence of the sponge metal jet (15) and which jet in the region or vicinity of that point of incidence, on the side facing the electrode(s) (6) of the electric-arc furnace (1), is shielded by the sponge metal jet (15) relative to the electrode(s) (6) in the form of a protective shield.

Abstract:

Process for Melting Sponge Iron And Electric-Arc Furnace for Carrying Out the Process

In a process for melting down sponge metal (11) in an electric-arc furnace (1) having at least one electrode (6), the sponge metal (11) is introduced into the electric-arc furnace (1) under formation of at least one sponge metal jet (15) which in the immediate vicinity of an electrode (6) hits the bath level (16) present in the electric-arc furnace (1), and for decarburization and/or intermixing the bath and/or charging energy oxygen is blown into the melt (7).

For a CO post-combustion, in addition to the oxygen introduced for decarburization and/or intermixing the bath and/or charging energy into the melt at least one jet (14) of oxygen or one jet (14) of an oxygen-containing gas is blown into the electric-arc furnace (1) at a low rate, which jet hits the bath level (16) in the region of the point of incidence of the sponge metal jet (15), which preferably is conveyed into the electric-arc furnace (1) by gravitation alone, and/or immediately adjacent to the point of incidence of the sponge metal jet (15) and which jet in the region or vicinity of that point of incidence, on the side facing the electrode(s) (6) of the electric-arc furnace (1), is shielded by the sponge metal jet (15) relative to the electrode(s) (6) in the form of a protective shield. (Fig. 1)

Process for Melting Sponge Iron And Electric-Arc Furnace for Carrying Out the Process

The invention relates to a process for melting down sponge metal, in particular sponge iron, in an electric-arc furnace having at least one electrode, wherein the sponge metal is introduced into the electric-arc furnace under formation of at least one sponge metal jet which in the immediate vicinity of an electrode hits the bath level present in the electric-arc furnace and wherein for decarburization and/or intermixing the bath and/or charging energy into the metal melt oxygen is blown into the melt, as well as to an electric-arc furnace for carrying out the process.

It is known (EP - 0 964 065 A1, EP - 0 418 656 A1) to introduce solids, such as steel works dusts, untreated filter dusts and/or scale or unreduced ore, into an electric-arc furnace, namely to blow them into a metal melt present in the electric-arc furnace. Here, it has turned out to be advantageous to supply, via a lance, oxygen above the bath level of the metal melt and within a slag layer situated above it and to thereby carry out in a region adjacent to the metal melt a post-combustion of carbon monoxide formed by a separate O_2 supply and to charge the heat quantity obtained in that post-combustion immediately into the metal melt.

Furthermore, it is known to provide post-combustion means for applying the CO post-combustion technology when smelting scrap. For this purpose, post-combustion nozzles and/or burners are fixedly installed in the electric-arc furnace. However, such means can not be used under flat-bath conditions.

The invention has as its object to make it possible to apply the CO post-combustion technology also to electric-arc furnaces which serve the purpose of melting down sponge metal, in particular sponge iron, under flat-bath conditions. With electric-arc furnaces for melting down sponge iron, sponge iron is introduced through a cover hole, which is arranged outside the center, namely roughly at the circumference of a cover heart, via a chute or slide, and this in large quantities of up to 7,000 kg/min. In practice, in the absence of specific measures, an average of 28 to 40 kg of sponge iron is introduced per MW of electric-power input and per minute. The sponge iron, which is in lumpy form (pellets and/or briquets) as well as, optionally, also in fine-particulate form, gets for example in the form of a trajectory parabola close to the center of the electric-arc furnace, that is, its energy center, in which one electrode or several electrodes are arranged. Hereby, a quick melting-down results. With a furnace of that kind, there is the problem that during improper introduction of oxygen for post-combustion purposes there may occur an increased electrode consumption by the

oxygen, a decrease in the metallic discharging by increased iron loss as well as an increase in the thermal stress of the wall and cover elements of the electric-arc furnace, which in general are water-cooled, without energy being additionally transferred to the molten metal.

The invention aims at avoiding these disadvantages and difficulties and has as its object to provide a process and an electric-arc furnace which enable a very efficient CO post-combustion when melting down sponge iron under flat-bath conditions, wherein introduction of the sponge metal into the energy center or its immediate vicinity should be possible.

According to the invention, this object is achieved in that in addition to the oxygen introduced for decarburization and/or intermixing the bath and/or charging energy into the metal melt at least one jet of oxygen or one jet of an oxygen-containing gas is blown into the electric-arc furnace at a low rate for a CO post-combustion, which jet hits the bath level in the region of the point of incidence of the sponge metal jet, which preferably is conveyed into the electric-arc furnace by gravitation alone, and/or immediately adjacent to the point of incidence of the sponge metal jet and which jet in the region or vicinity of that point of incidence, on the side facing the electrode(s) of the electric-arc furnace, is shielded by the sponge metal jet relative to the electrode(s) in the form of a protective shield.

Hereby, the CO forming during the impact of the carbon-containing sponge iron on the oxygen-containing slag and the subsequent melting-down is subjected to a post-combustion with oxygen to form CO_2, and the energy thus being released is additionally imparted to the sponge iron of the feed jet and to the slag and/or the bath. The hot slag thereby exhibits an improved foaming behavior and better envelops the electric arc(s), whereby the radiation of heat to the water-cooled wall and cover elements is reduced. All in all, energy savings of $\geq$ 35 kWh/t of liquid steel result therefrom.

Thus, according to the invention, at least one separate jet of oxygen or jet of an oxygen-containing gas is introduced into the electric-arc furnace only for the CO post-combustion; here, it is essential that this/these oxygen jet(s) is/are directed into the energy center and into the region and/or immediate vicinity of the point of incidence of the sponge iron on the melt and that a protection of the electrodes from direct contact with oxygen is nonetheless provided.

The oxygen jet or jet of an oxygen-containing gas, which is additionally blown in, preferably is blown into the electric-arc furnace at a subsonic speed.

Preferably, the oxygen jet or jet of an oxygen-containing gas, which is additionally blown in, is blown in under a low pressure, preferably under a pressure of 6 bars at the most, so that the slag is not displaced by the oxygen jet or jet of an oxygen-containing gas, additionally introduced for the CO post-combustion, whereby the electric arcs effectively remain enveloped by foamed slag. By a low pressure, the pressure at which no supersonic speed is attained with a predetermined nozzle diameter is understood.

Suitably, the sponge iron is introduced into the electric-arc furnace in lumpy form, preferably as pellets and/or briquets, and, optionally, partly in the form of fines.

According to a preferred embodiment, the oxygen jet or jet of an oxygen-containing gas from roughly half the free height of the interior of the electric-arc furnace to the point of incidence on the bath level is shielded by the sponge metal jet relative to the electrode(s) at least on the side facing the electrode(s), "roughly" comprising ± 20%, preferably ± 10%.

An electric-arc furnace for carrying out the process according to the invention, comprising at least one electrode and a cover charging hole for charging sponge metal by gravitation and comprising an oxygen feeding means for introducing oxygen into the metal melt, is characterized by at least one oxygen lance which through a cover opening can be brought into a position projecting into the inside of the furnace, which position is oriented in such a manner that the oxygen jet, seen from one electrode or the electrodes, at least in the region of the point of incidence of the sponge metal on the bath level is shielded relative to the electrode(s) by the sponge metal falling into the electric-arc furnace by gravitation.

For the exact positioning of the oxygen supply, the oxygen lance is movable relative to the electric-arc furnace, preferably pivotable and forwardly and backwardly displaceable.

In the following, the invention will be explained in more detail with reference to exemplary embodiments represented in the drawings, wherein Fig. 1 shows a central vertical section of an electric-arc furnace (three-phase furnace) according to a first embodiment and Figs. 2 and 4 show a diagrammatic top view of a three-phase or direct-current furnace according to another embodiment. By way of a detail III of Fig. 1, Fig. 3 renders the operating principle of the invention in diagrammatic representation. Figs. 5 and 6 illustrate a diagrammatic top view and a vertical section along line VI-VI of Fig. 5 of an inclined electrode furnace according to a further embodiment of the invention.

An electric-arc furnace 1, bottom portion 2 of which has a refractory lining, has a cover 3, which, together with water-cooled panels 4, forming the side walls of electric-arc furnace 1, forms the furnace chamber. Cover 3 itself is formed by a cover heart 5 and a ring of water-cooled panels 4a, through which cover heart 5 according to Fig. 1 there projects an electrode 6, which is arranged in the center of electric-arc furnace 1 and which draws an electric arc to the surface of metal melt 7, covered by a slag layer 8. Into metal melt 7 there project lances 9, which feed oxygen into metal melt 7 and through which oxygen is introduced for decarburization, intermixing the bath and charging energy into metal melt 7.

At the side of cover heart 5, cover 3 has a cover opening 10, through which sponge iron 11 in the form of pellets and/or briquets as well as, optionally, also in the form of fines is conducted into the inside of the furnace via chutes or slides 12. Thus, departing from cover hole 10, sponge iron 11 in the form of a trajectory parabola falls into the vicinity of electrode 6, that is, into the energy center of electric-arc furnace 1 or its immediate vicinity, so that a quick melting-down of sponge metal 11 is ensured.

According to the invention, there further projects through cover 3 at least one oxygen lance 13, through which pure oxygen or an oxygen-containing gas is blown into electric-arc furnace 1 at a low speed, for example 200 m/s, and at a maximum pressure of 6 bars, preferably 3-6 bars. That oxygen lance, 13, is oriented in such a manner that oxygen jet 14 likewise hits bath surface 16 in roughly the region where sponge iron jet 15 hits the bath surface; however, the orientation of oxygen lance 13 is chosen such–and this is essential to the invention–that sponge iron jet 15 between electrode 6 and oxygen jet 14 forms a protective shield which prevents immediate contact of the oxygen blown in with electrode 6.

This is done by accordingly constructing cover hole 10 for feeding sponge iron 11, so as to obtain a protective shield of sponge iron 11, which is as effective as possible and which improves the energy absorption from the post-combustion and protects electrode(s) 6 from oxygen jet 14.

As can be seen especially in Fig. 3, mainly the CO formed in roughly the region of the energy center, that is, in the region of the point of incidence of sponge metal 11 on bath level 16, immediately after ascending through slag layer 8 is subjected to post-combustion by the oxygen offer present in that region to form CO_2.

Oxygen lance 13 is a specifically positionable water-cooled post-combustion lance which advantageously is mounted on a manipulator, so that the oxygen jet can be oriented exactly

as desired within the furnace chamber. Preferably, the manipulator is mounted on a cover supporting arm of the furnace in the region of furnace cover 3, namely in the vicinity of cover hole 10 for introducing sponge iron 11.

Post-combustion only is started when sponge metal 11 already falls into the inside of the electric-arc furnace with a specific minimum rate, such as around 1,000 kg/min, and when there is already oxygen being blown into iron bath 7. Hereby, the function of sponge iron jet 15, generated between the oxygen jet and the electrode, as a protective shield is ensured.

In Fig. 2 it can be seen that sponge iron jet 15, introduced into the energy center of the electric-arc furnace whenever possible, forms a protective shield for the three electrodes, 6, so that an immediate contact of electrodes 6 with oxygen fed via oxygen lances 13 can be avoided.

As shows the embodiment of Fig. 4, the same idea is also applied to an electric-arc furnace 1 driven by direct current, in which embodiment sponge iron jet 15 shields oxygen jets 14, supplied by oxygen lances 13, relative to single electrode 6.

In an inclined-electrode furnace (COMELT) having inclined electrodes 6 evenly distributed along the furnace circumference, according to Figs. 5 and 6, sponge iron 11, in contrast to the exemplary embodiments represented in the other figures, does not fall into the energy center, located within the circle circumference formed by the electrode ends, in the form of a trajectory parabola but vertically and centrally in free fall. Post-combustion lances 13, arranged for example in the middle of two inclined electrodes 6 on cover 3 and whose number is three in the example represented in Fig. 5, likewise blow oxygen into the region of the point of incidence of sponge iron jet 15 at a low pressure and a low rate, but without aiming into the direction of an electrode 6. In spite of its position surrounded by inclined electrodes 6, vertically falling sponge iron jet 15 forms, with its periphery in the form of a cone envelope, a protective shield between oxygen jets 14 of oxygen lances 13 and a part of electrodes 6. Due to its/their oblique arrangement, electrode(s) 6 not protected by a protective shield of sponge metal do(es) not undergo a bigger waste than the other electrodes 6.

The configurations of sponge iron jet 15 and oxygen jets 14 suitably are chosen such that a protection by sponge iron jet 15 is ensured up to a specific height above bath level 16, namely up to half ± 20%, preferably ± 10%, the free height, H, of the interior of electric-arc furnace 1.

For the CO post-combustion there are blown in between 300 Nm^3/h and 1300 Nm^3/h of oxygen or oxygen-containing gas per oxygen lance 13 at a pressure of–as already mentioned–6 bars at the most. Hereby, oxygen jet 14, when hitting slag layer 8, is prevented from exercising a negative influence on the foaming behavior or penetrating or displacing the slag. Oxygen lance 13 is equipped with a nozzle having a diameter of between 20 and 60 mm. Preferably, it is made of copper.

The oxygen blowing rate of the post-combustion lance(s) is controlled stepwise and is guided by the following parameters:

- sponge iron conveying rate
- sum of the oxygen blowing rate via the refining lances being employed
- carbon content of the sponge metal
- waste gas analysis

At a conveying rate of for example 3 t of sponge iron/min and an oxygen blowing rate for the refining of about 3,000 Nm^3/h and a carbon content of the sponge iron of about 2%, for the CO post-combustion there are blown in 13,800 Nm^3/h per oxygen lance under low pressure, preferably 3-6 bars, when two oxygen lances 13 are provided.

Claims:

1. A process for melting down sponge metal (11), in particular sponge iron (11), in an electric-arc furnace (1) having at least one electrode (6), wherein the sponge metal (11) is introduced into the electric-arc furnace (1) under formation of at least one sponge metal jet (15) which in the immediate vicinity of an electrode (6) hits the bath level (16) present in the electric-arc furnace (1) and wherein for decarburization and/or intermixing the bath and/or charging energy into the metal melt (7) oxygen is blown into the melt (7), characterized in that in addition to the oxygen introduced for decarburization and/or intermixing the bath and/or charging energy into the metal melt (7) at least one jet (14) of oxygen or one jet (14) of an oxygen-containing gas is blown into the electric-arc furnace (1) at a low rate for a CO post-combustion, which jet hits the bath level (16) in the region of the point of incidence of the sponge metal jet (15), which preferably is conveyed into the electric-arc furnace (1) by gravitation alone, and/or immediately adjacent to the point of incidence of the sponge metal jet (15) and which jet in the region or vicinity of that point of incidence, on the side facing the electrode(s) (6) of the electric-arc furnace (1), is shielded by the sponge metal jet (15) relative to the electrode(s) in the form of a protective shield.

2. A process according to claim 1, characterized in that the oxygen jet (14) or jet (14) of an oxygen-containing gas, which is additionally blown in, is blown into the electric-arc furnace (1) at a subsonic speed.

3. A process according to claim 1 or 2, characterized in that the oxygen jet (14) or jet (14) of an oxygen-containing gas, which is additionally blown in, is blown in under a low pressure, preferably under a pressure of 6 bars at the most.

4. A process according to one or several of claims 1 to 3, characterized in that sponge iron (11) is introduced into the electric-arc furnace in lumpy form, preferably as pellets and/or briquets, and, optionally, partly in the form of fines.

5. A process according to one or several of claims 1 to 4, characterized in that the oxygen jet (14) or jet (14) of an oxygen-containing gas from roughly half the free height (H) of the interior of the electric-arc furnace (1) to the point of incidence on the bath level (16) is shielded by the sponge metal jet (15) relative to the electrode(s) at least on the side facing the electrode(s) (6).

6. An electric-arc furnace (1) for carrying out the process according to one or several of claims 1 to 5, comprising at least one electrode (6) and a cover charging hole (10) for charging sponge metal (11) by gravitation and comprising an oxygen feeding means (9) for introducing oxygen into the metal melt (7), characterized by at least one oxygen lance (13) which through a cover opening can be brought into a position projecting into the inside of the furnace, which position is oriented in such a manner that the oxygen jet (14), seen from one electrode or the electrodes (6), at least in the region of the point of incidence of the sponge metal (11) on the bath level (16) is shielded relative to the electrode(s) by the sponge metal (11) falling into the electric-arc furnace (1) by gravitation.

7. An electric-arc furnace according to claim 6, characterized in that the oxygen lance (13) is movable relative to the electric-arc furnace (1), preferably pivotable and forwardly and backwardly displaceable.

Fig. 1

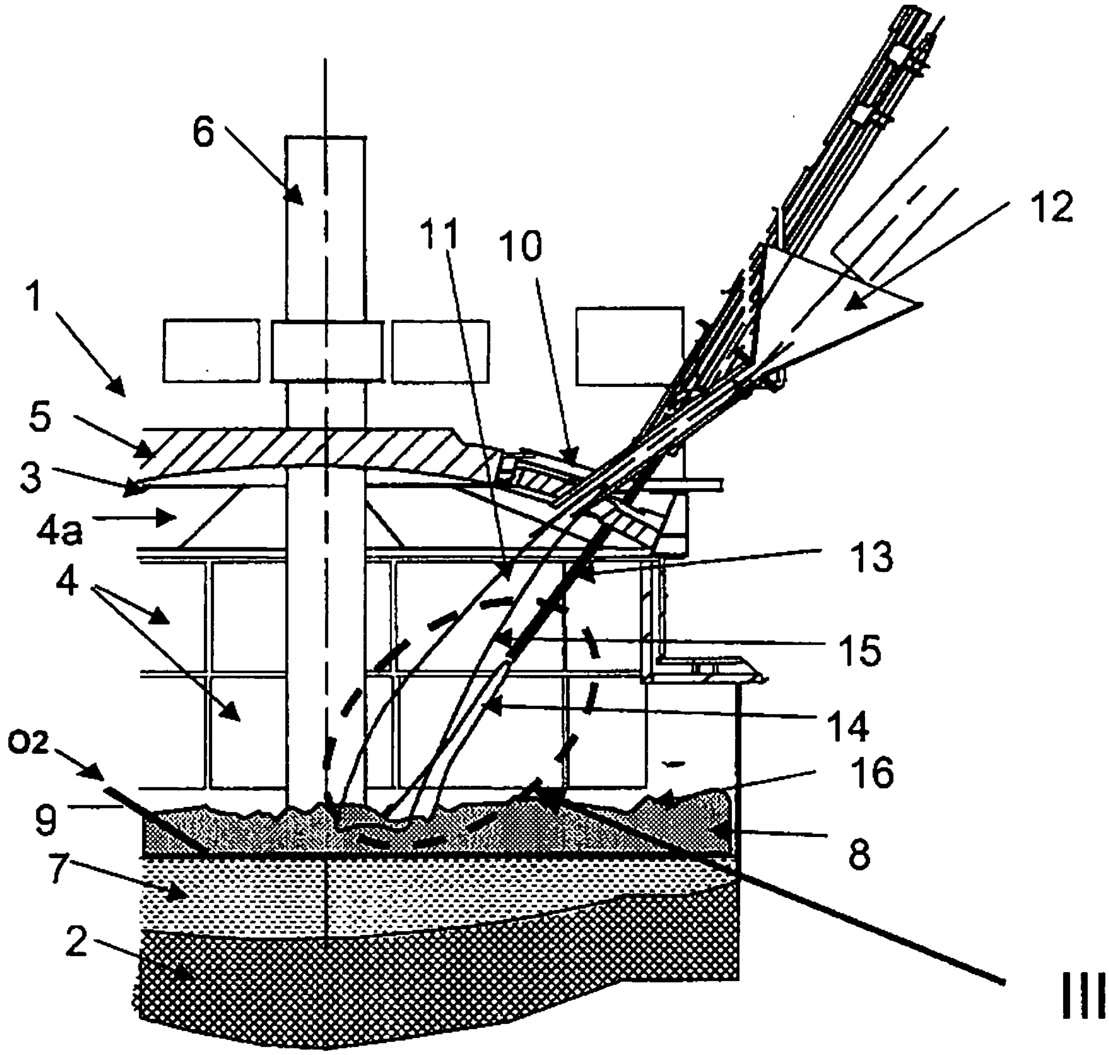


Fig. 2

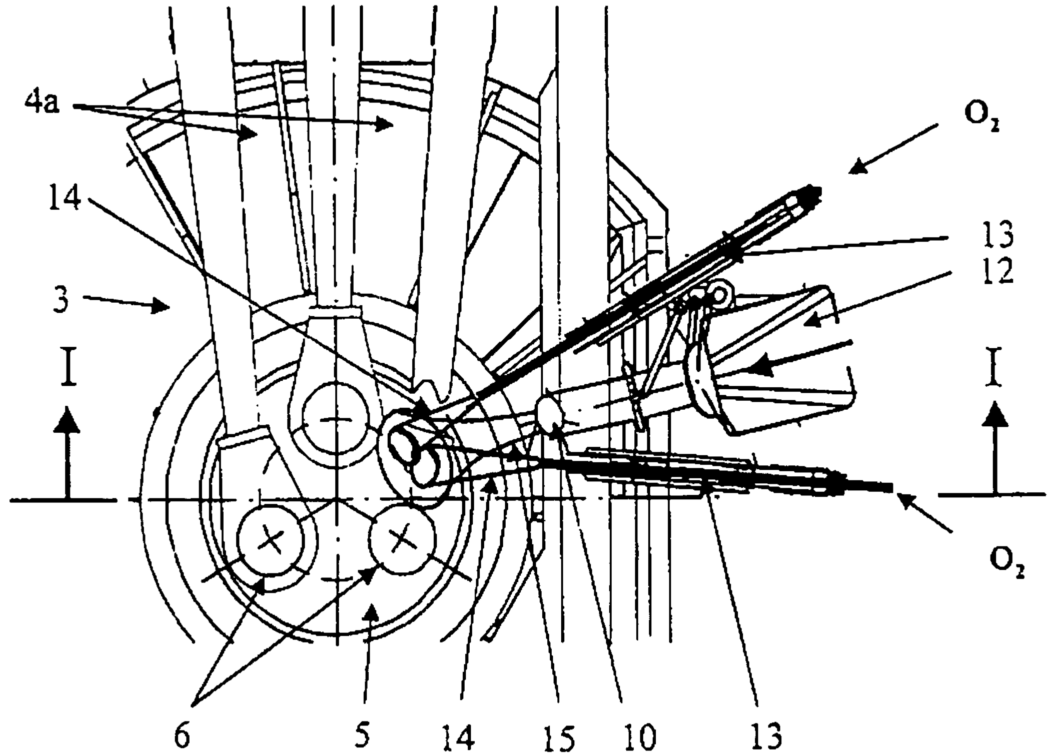

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Fig. 3

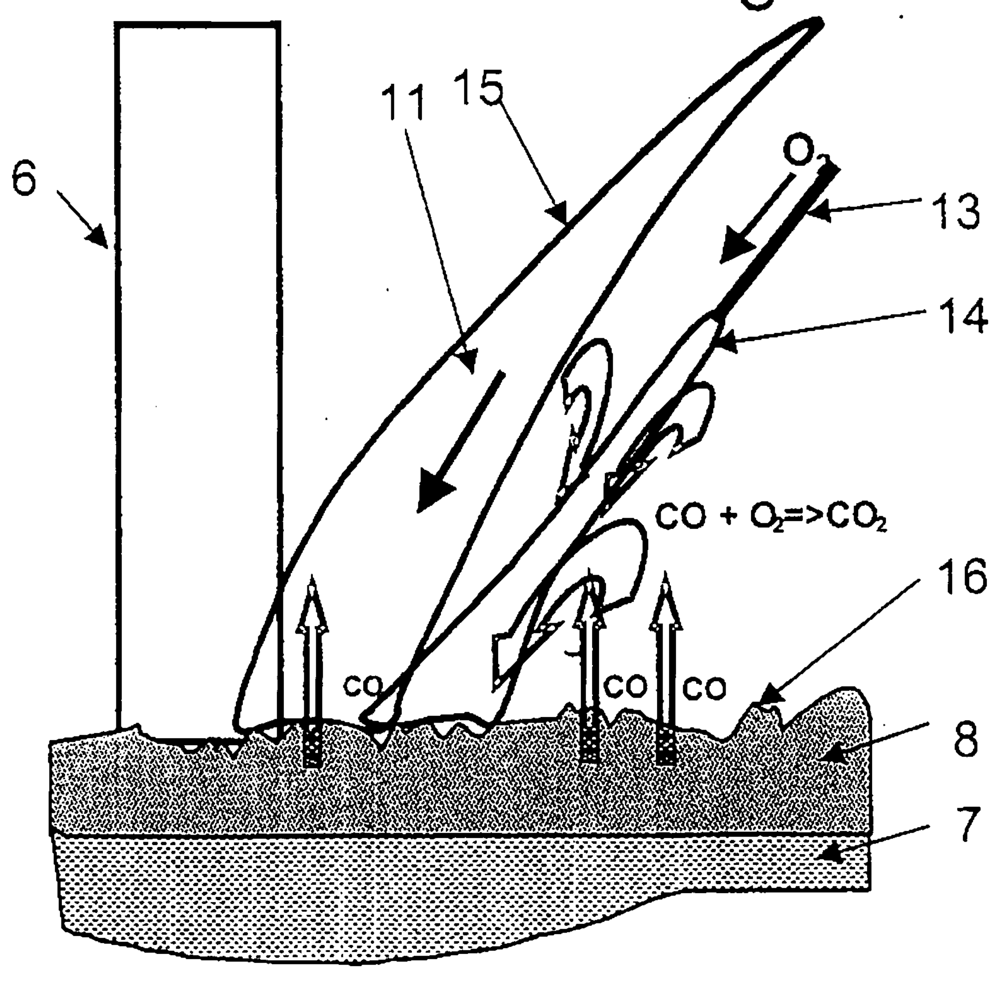
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Fig. 4

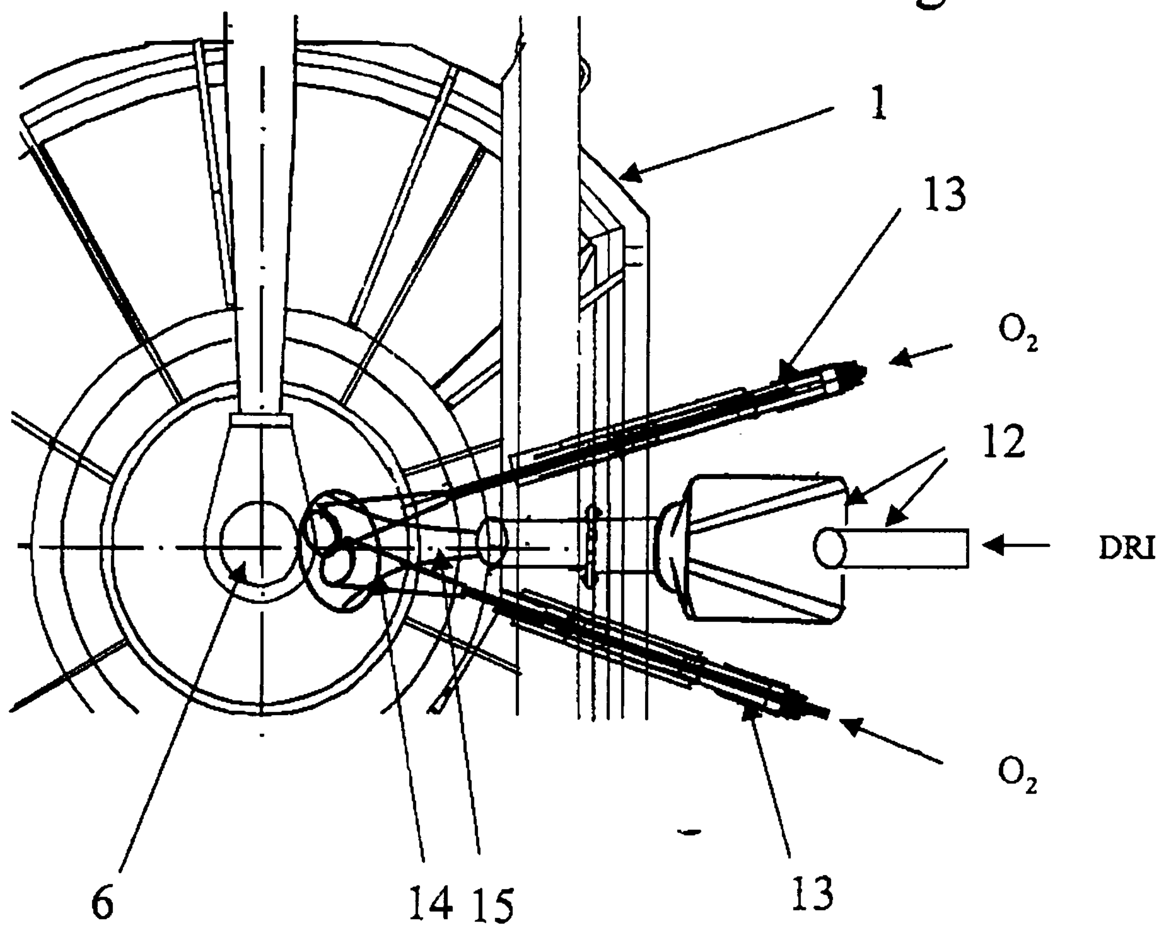


Fig. 5

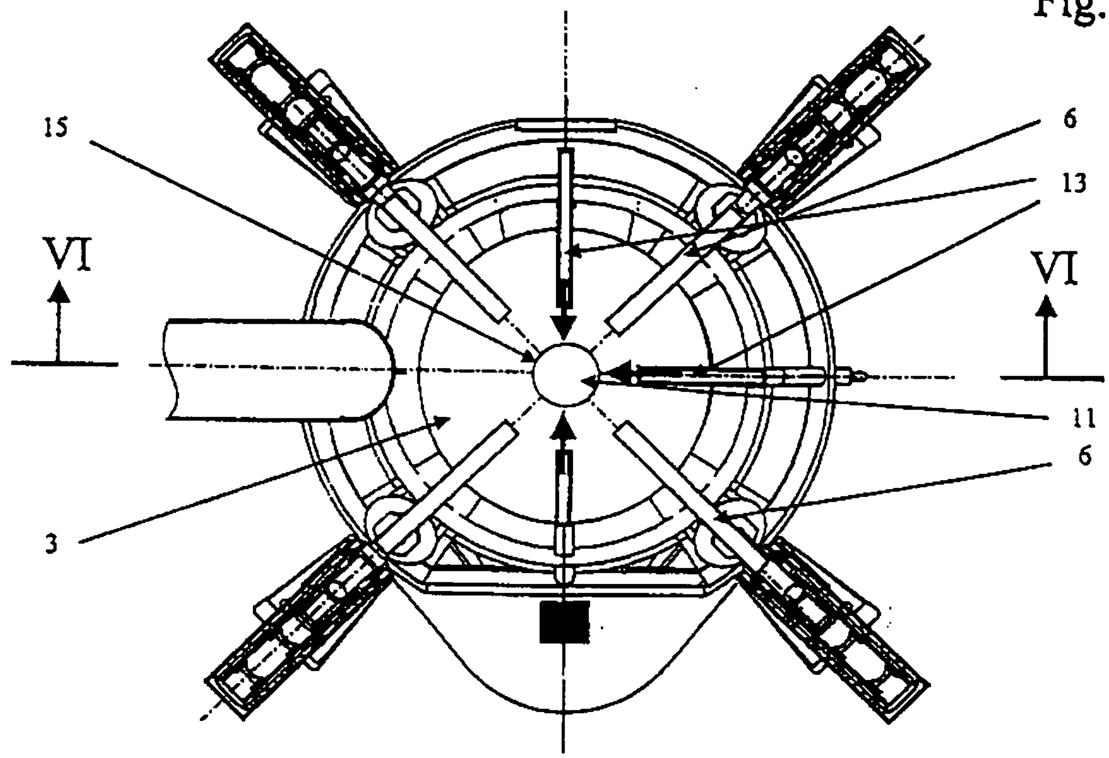
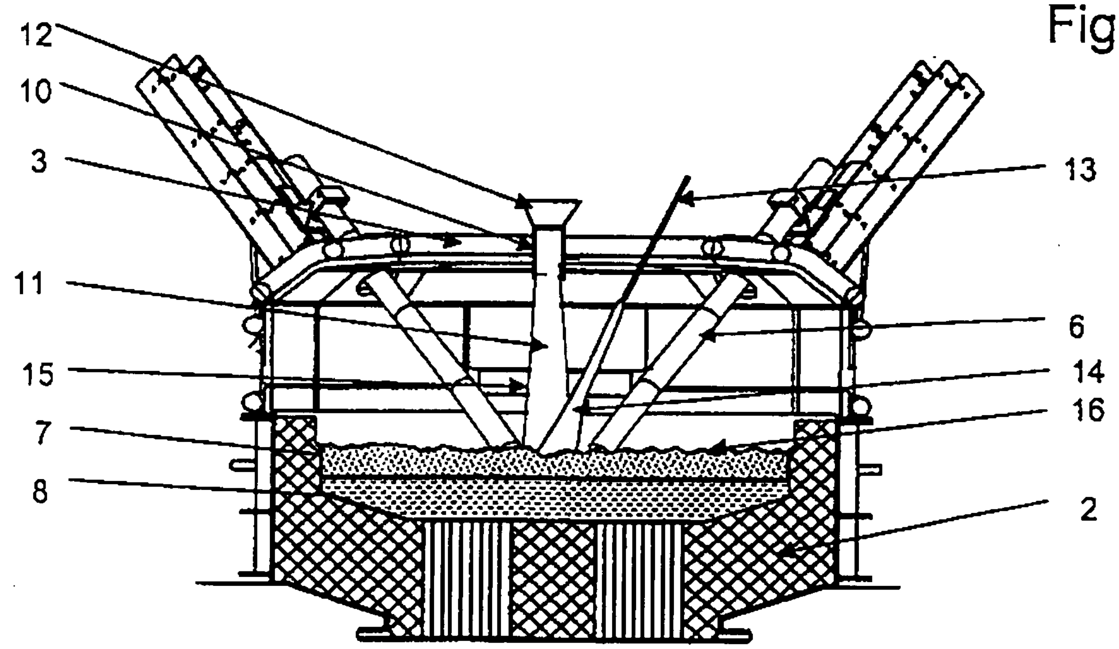
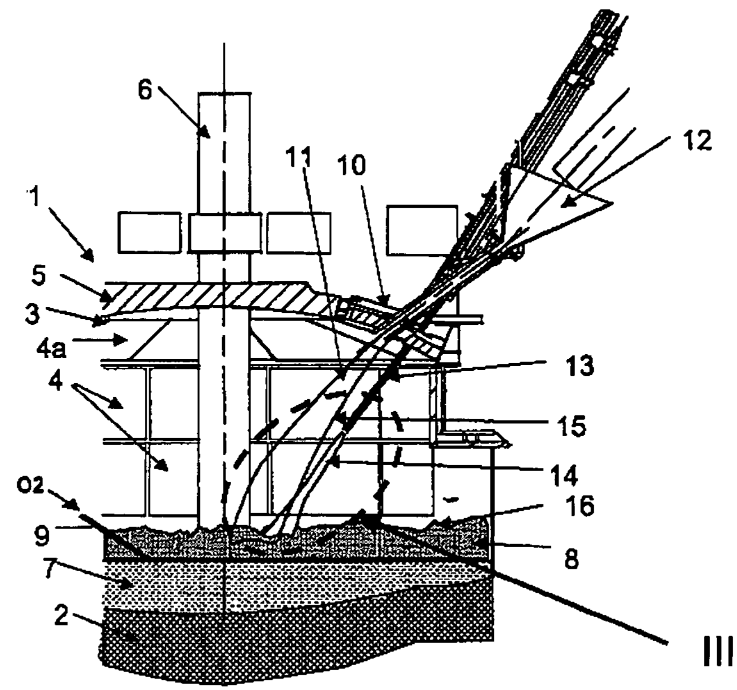


Fig. 6

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